OPTOELECTRONICS PACKAGING FOR EFFICIENT CHIP-TO-WAVEGUIDE COUPLING

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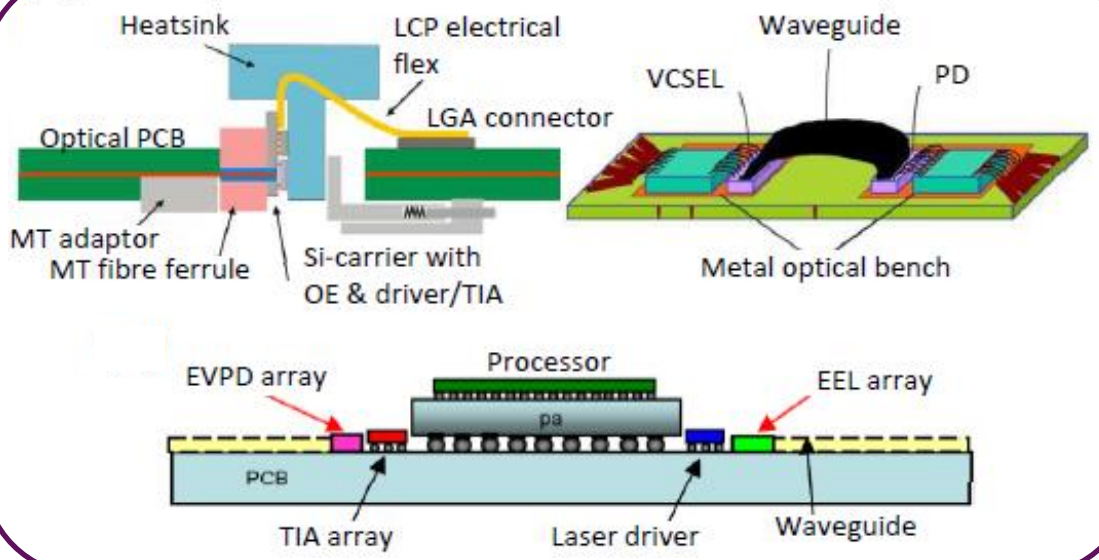
OPTOELECTRONICS PACKAGING

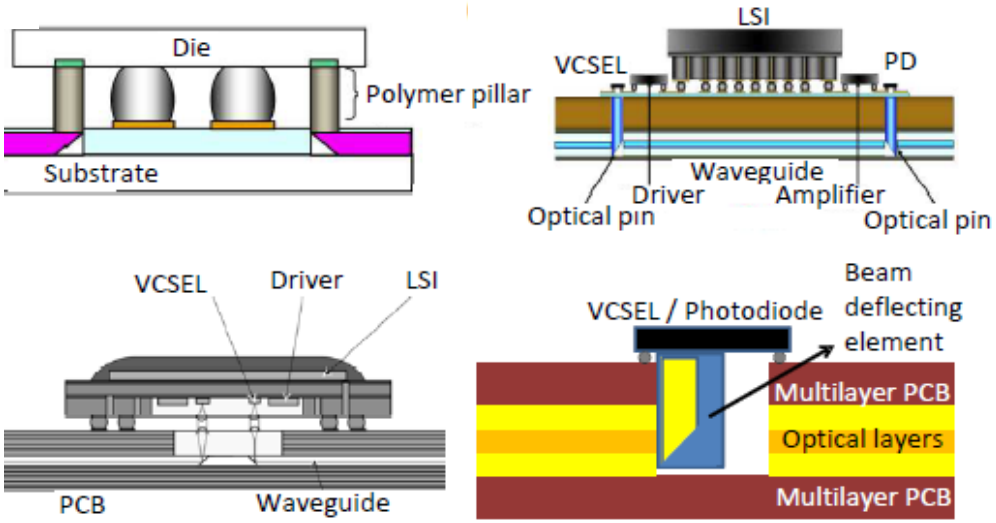


In-plane coupling approach schemes

IBM, ETRI, Georgia Inst. of Technol.

Vertical light confinement between optoelectronics and waveguides

Fujitsu, Tokai Univ., NTT, Siemens C-LAB



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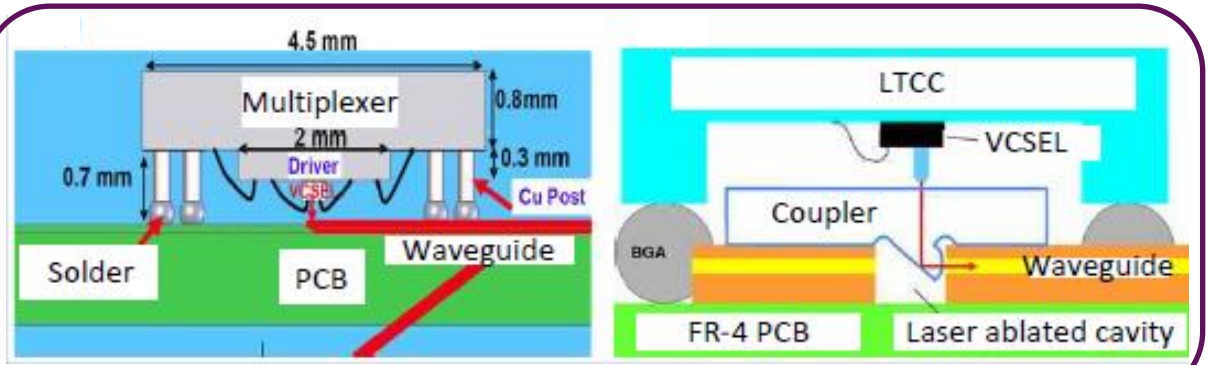
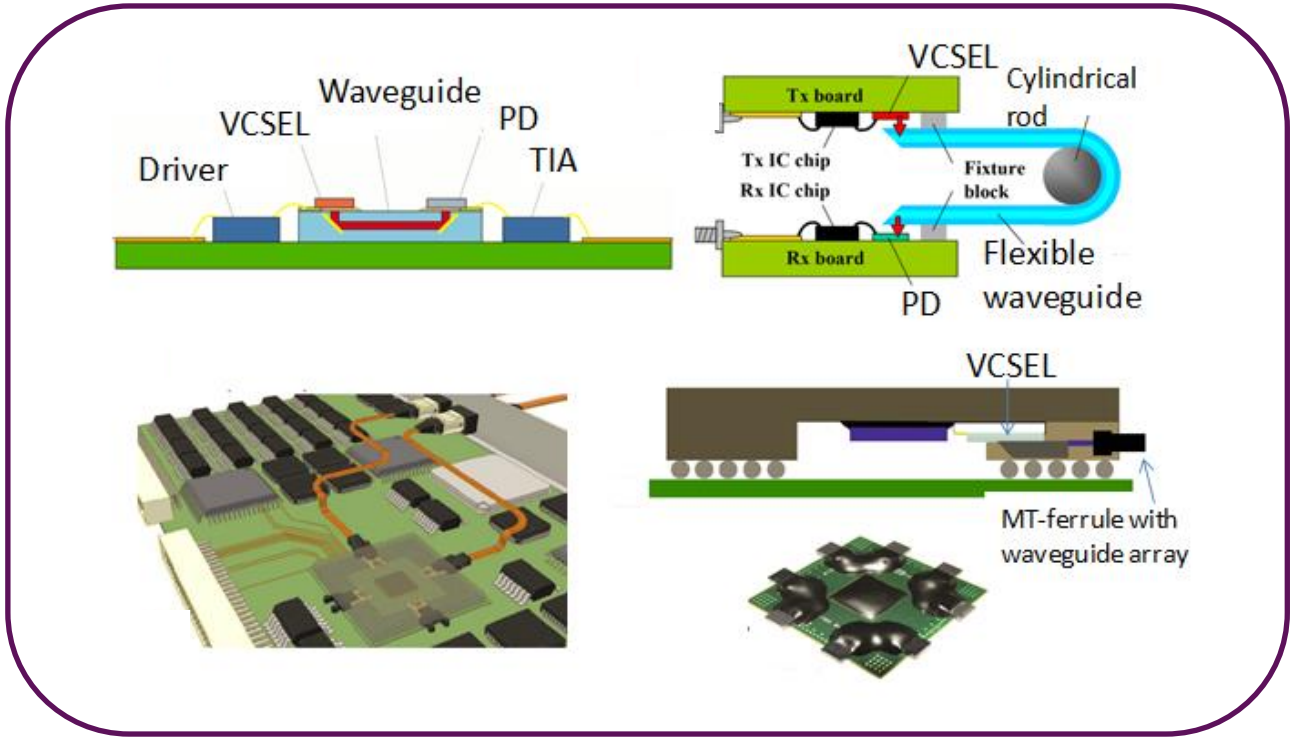


Vertical proximity coupling

Institute of Microelectronics (Singapore), Univ. Oulu.

Separate waveguide PCB approach

Central Glass Co., Ltd. (Japan), Korea Photonics Technol. Inst., Reflexphotonics



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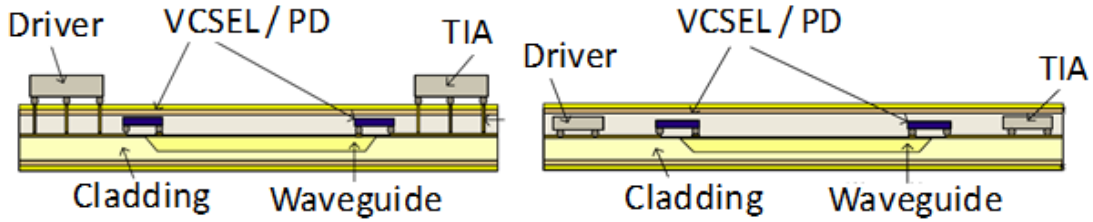
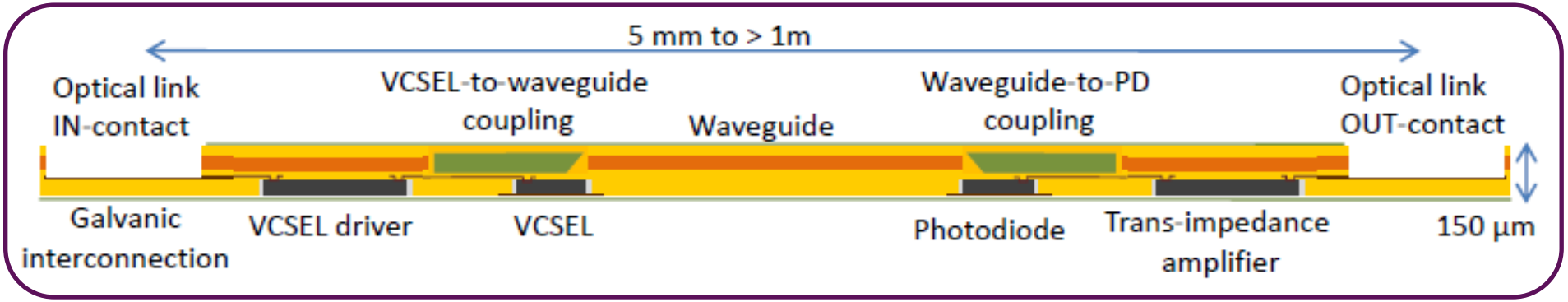


Embedding of optoelectronics in RCC laminates

Inha Univ. (South Korea)



Embedding of optoelectronics in flex substrates

Ghent Univ. / imec

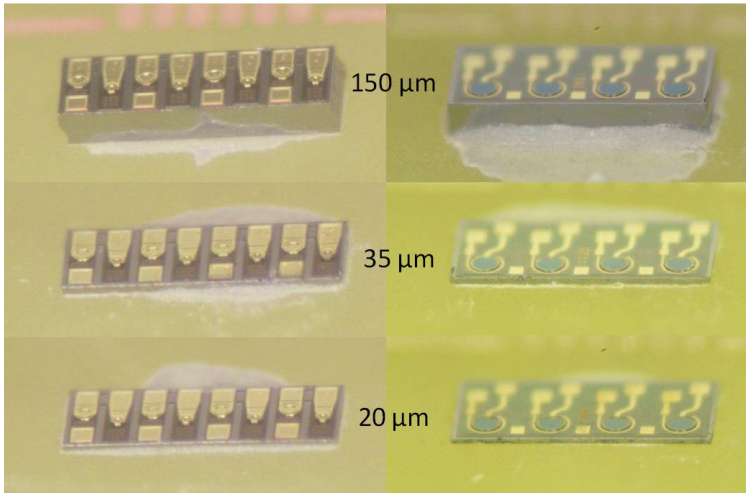
ULTRA-THIN OPTOELECTRONIC CHIP PACKAGE

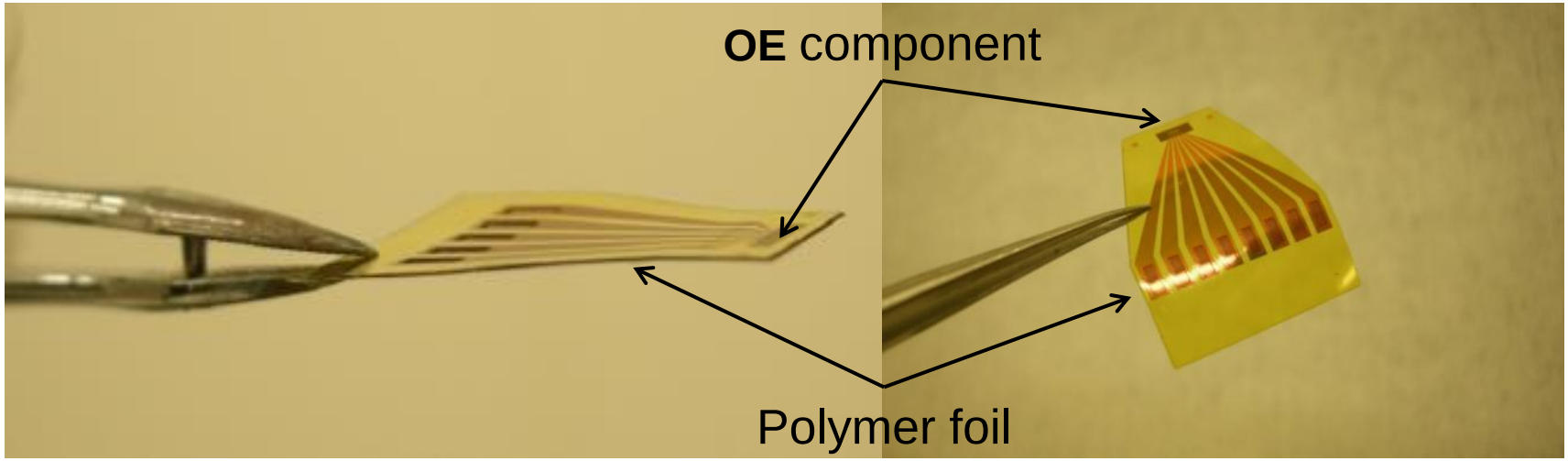
"Ultra thin optoelectronic package"

- Thinned commercial (opto)electronic components
- Embedded in **thin** & **flexible** polymer **foils**

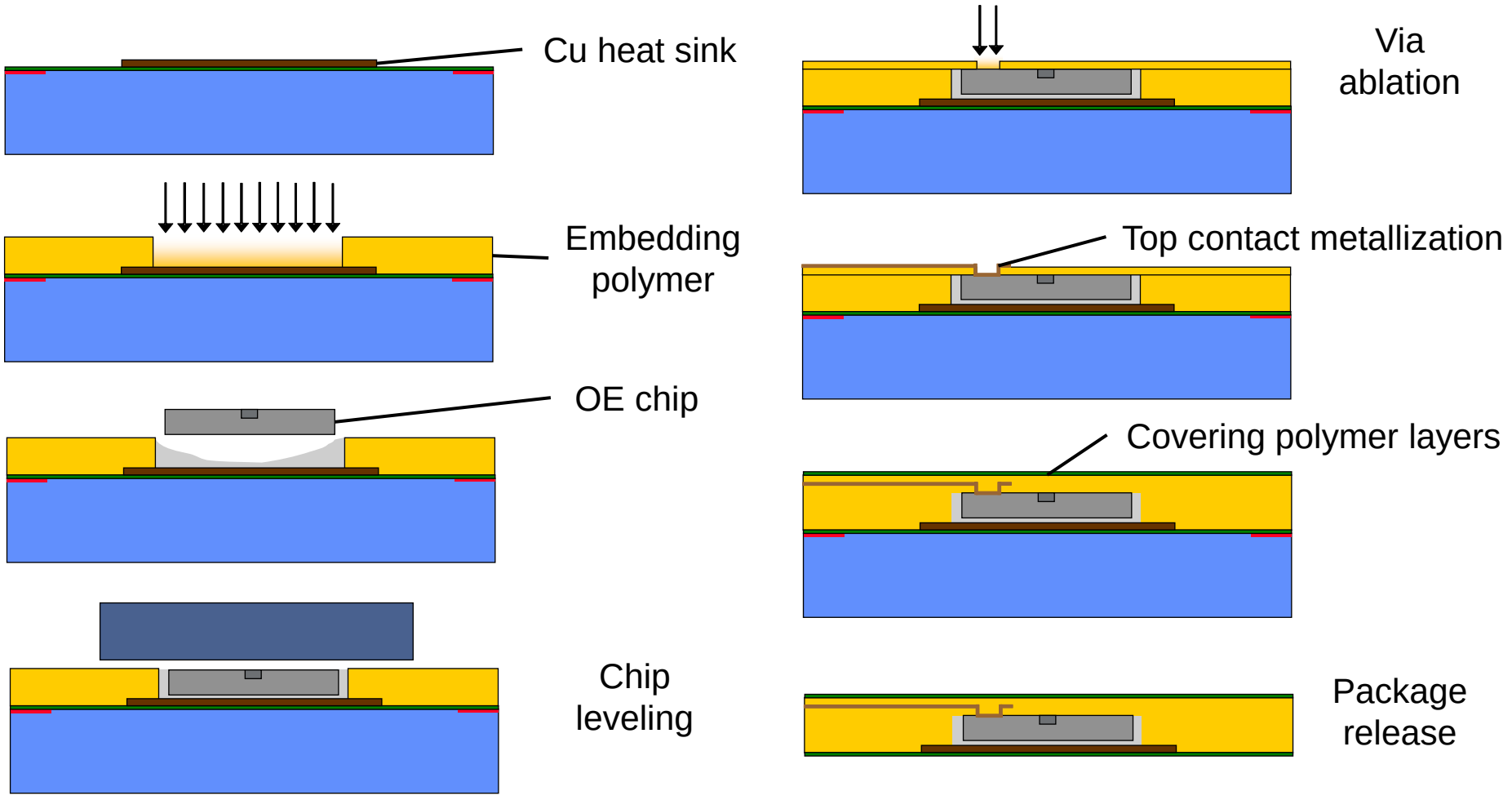
Component (bare die) thickness ~20µm

Total thickness ~40µm





ULTRA-THIN OPTOELECTRONIC CHIP PACKAGE

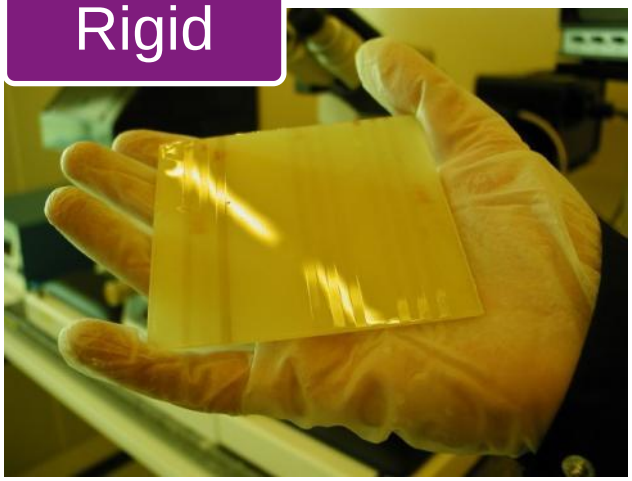


Precise process flow depends on substrate, polymer and component

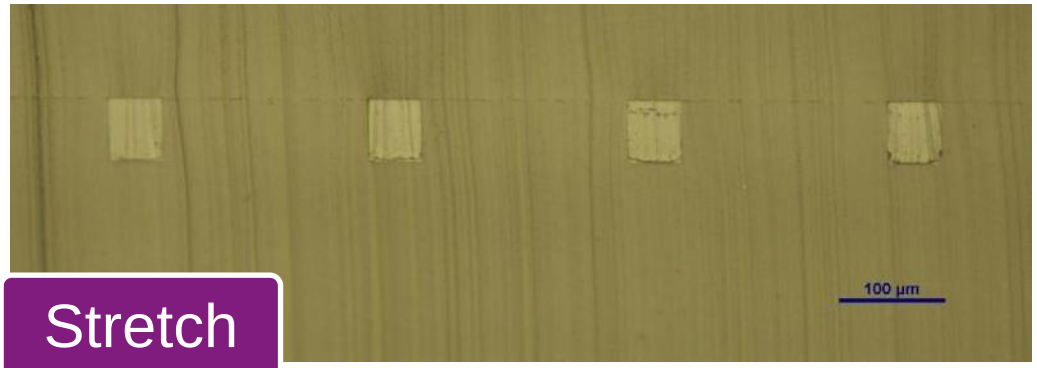
INTEGRATION WITH POLYMER OPTICAL WAVEGUIDES

- Acrylate, epoxy, silsesquioxanes, or silicone based
- Typical propagation loss below 0.1dB/cm

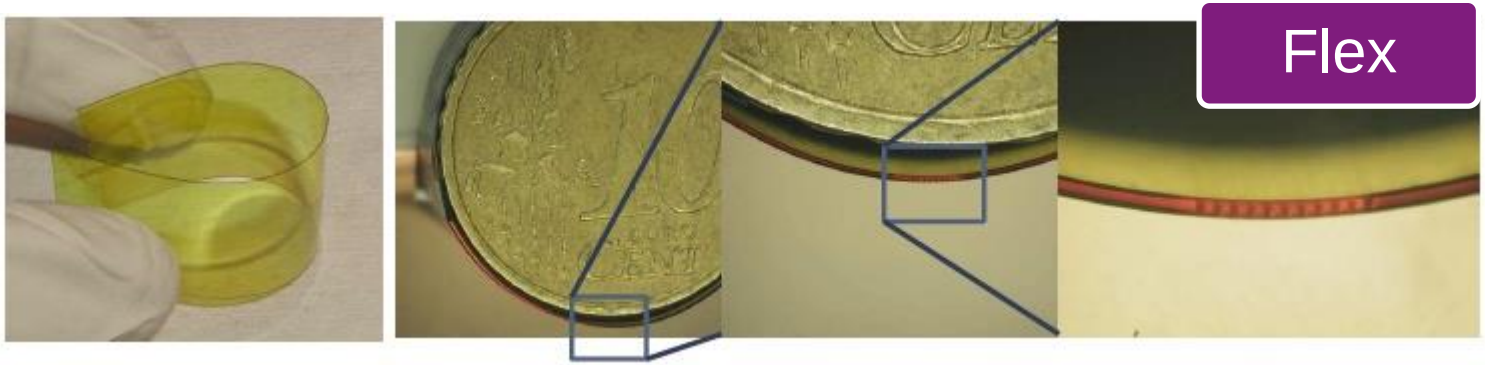
Rigid



Additional bending and stretching loss



Stretch

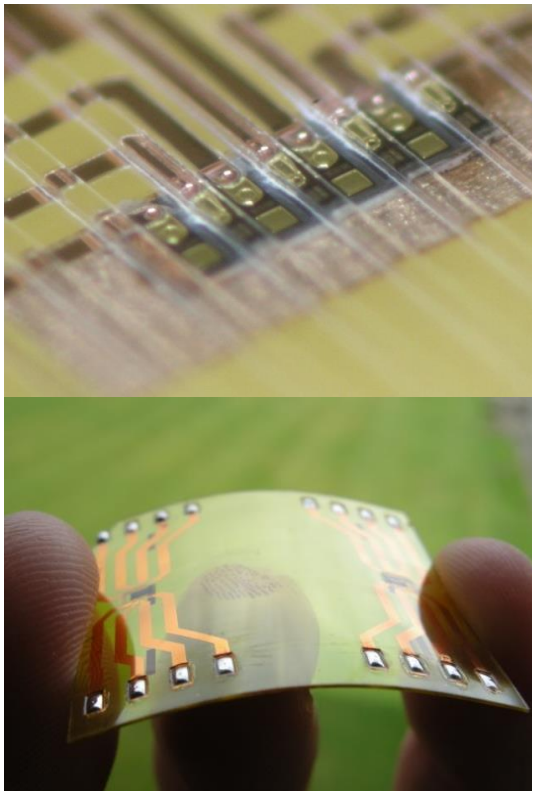


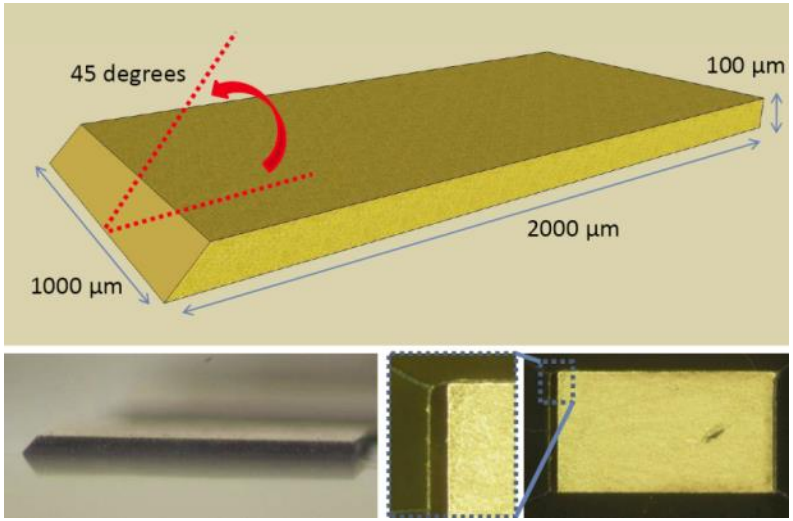
Flex

INTEGRATION WITH POLYMER OPTICAL WAVEGUIDES

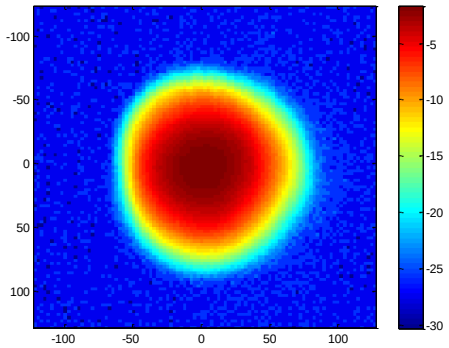
Sequential build-up approach

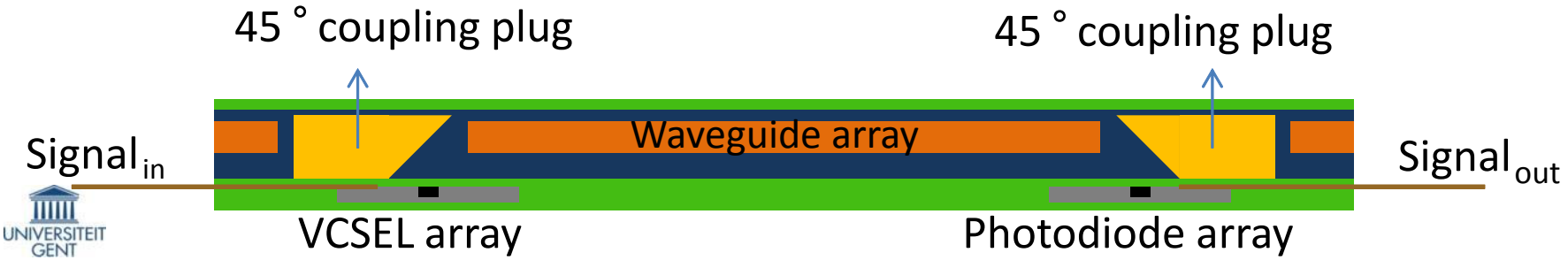
- Typical total optical loss 6dB





Mirror loss 0.5 dB



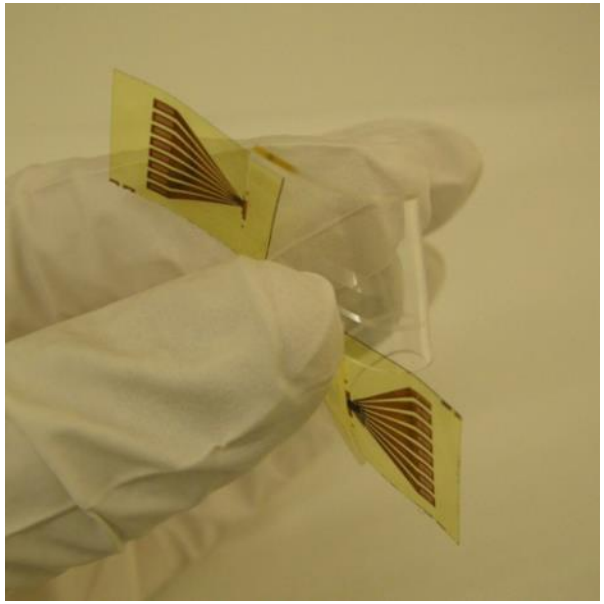


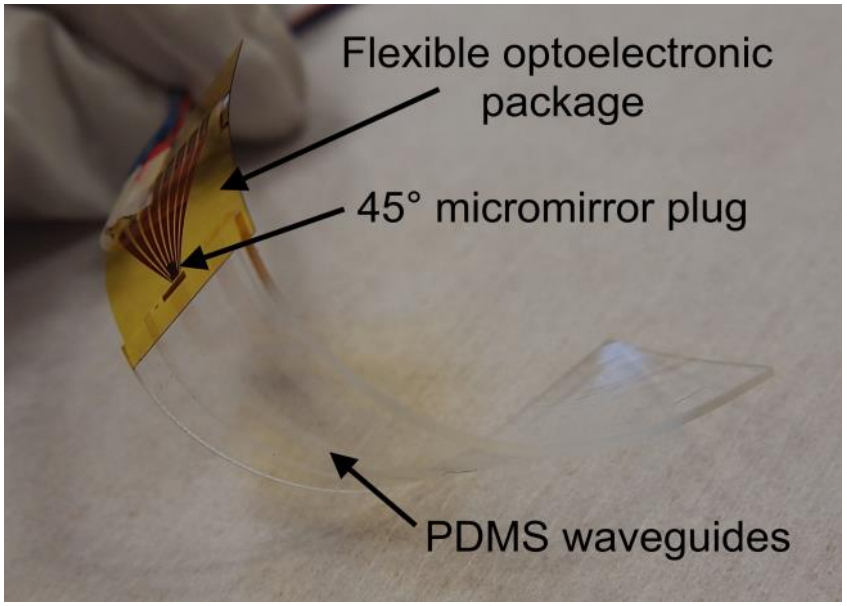
INTEGRATION WITH POLYMER OPTICAL WAVEGUIDES

Modular approach

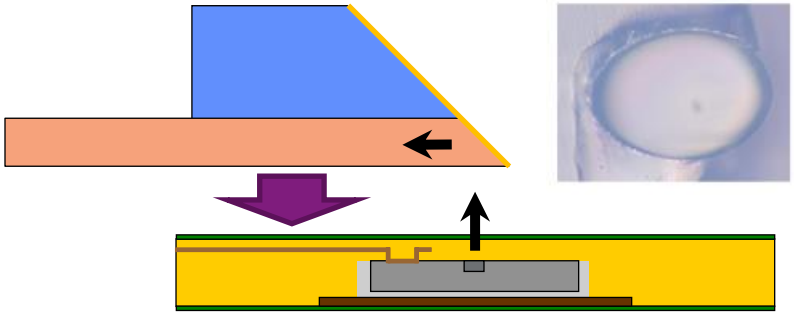
- Typical total optical loss 3dB

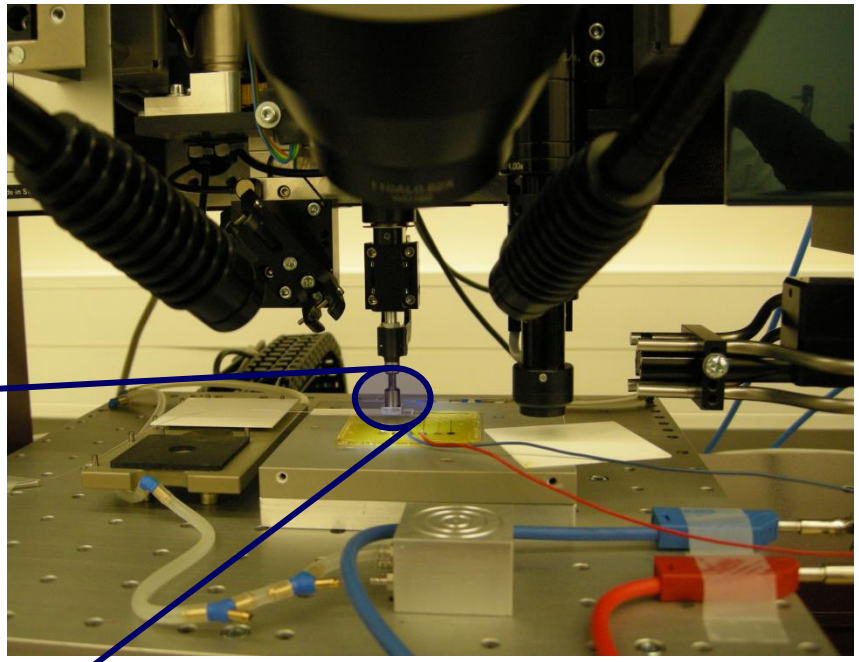
Stretching up to 30% without significant loss

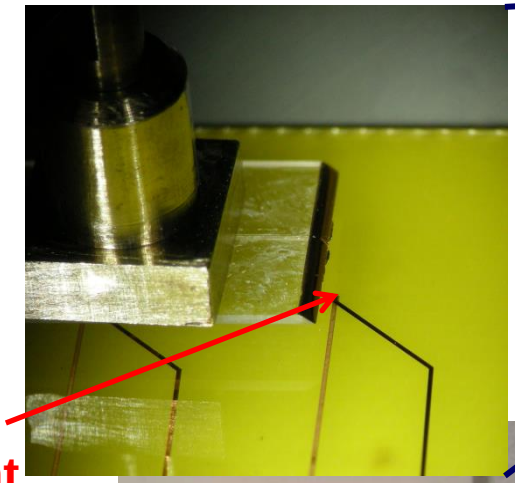




INTEGRATION WITH OPTICAL FIBERS

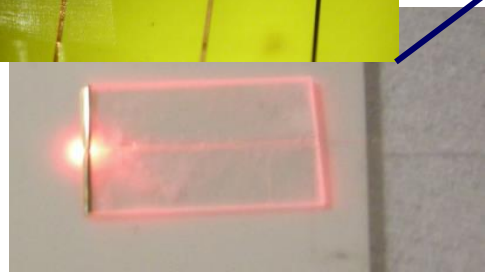


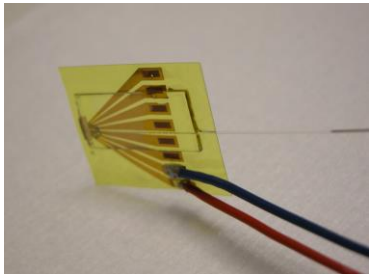


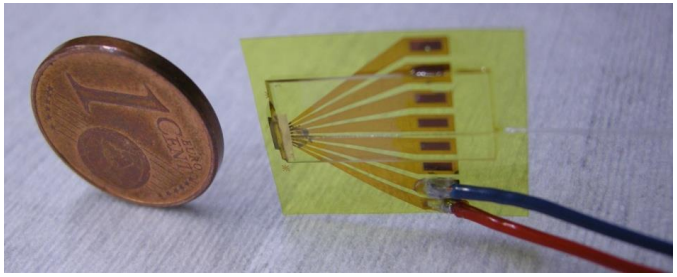


assembly based on
adapted flip chip process

OE component







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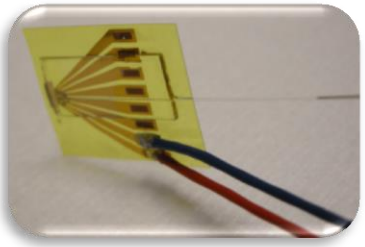
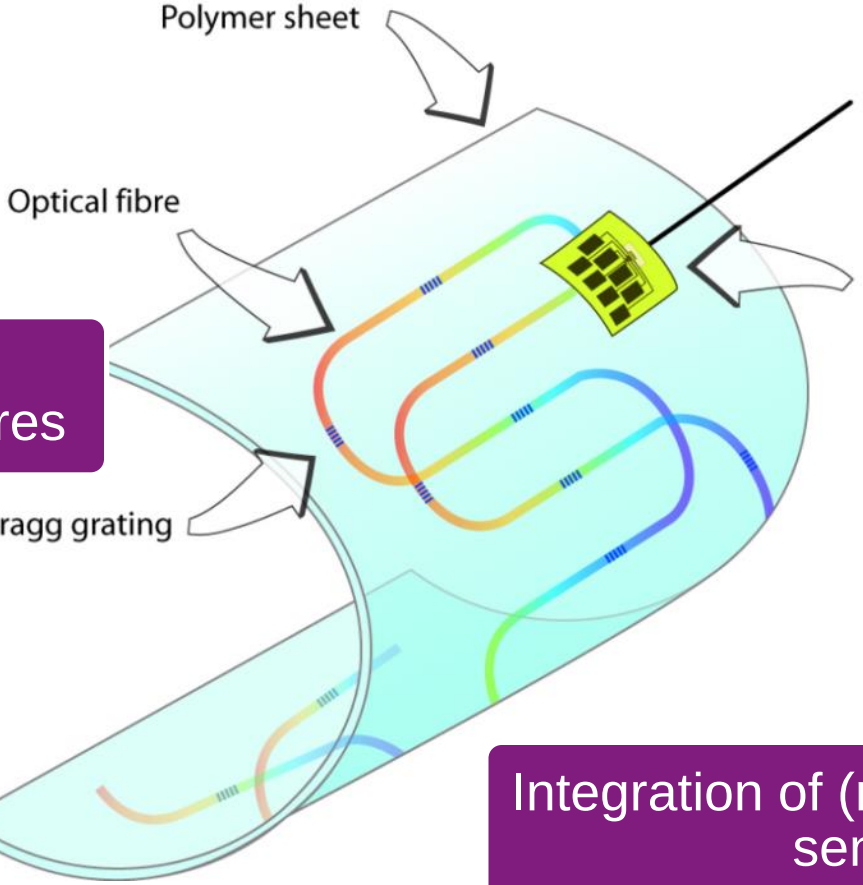
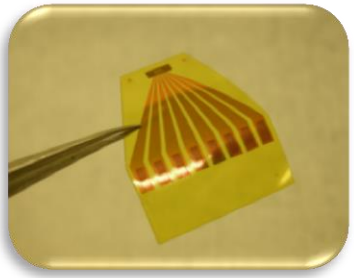
EU PROJECT PHOSFOS
PHOTONIC SKINS FOR OPTICAL SENSING

PHOSFOS
Photonic Skins For Optical Sensing

Integration of optoelectronic chips







Integration of coupling structures

Integration of (multiplexed) fiber sensors

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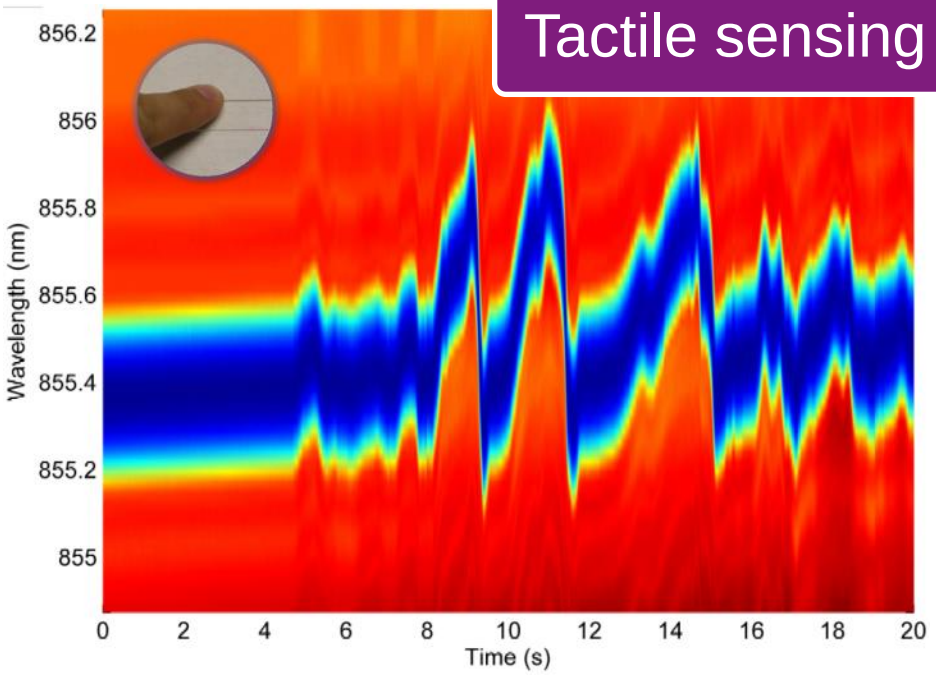
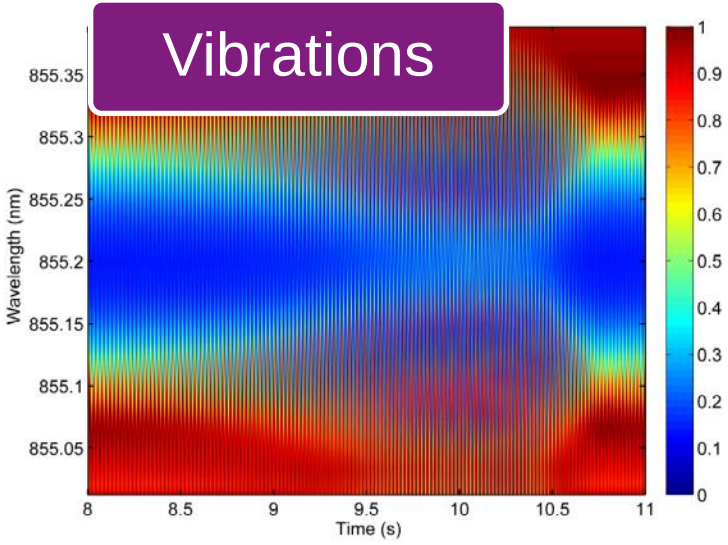
PHOTONIC SKINS FOR OPTICAL SENSING

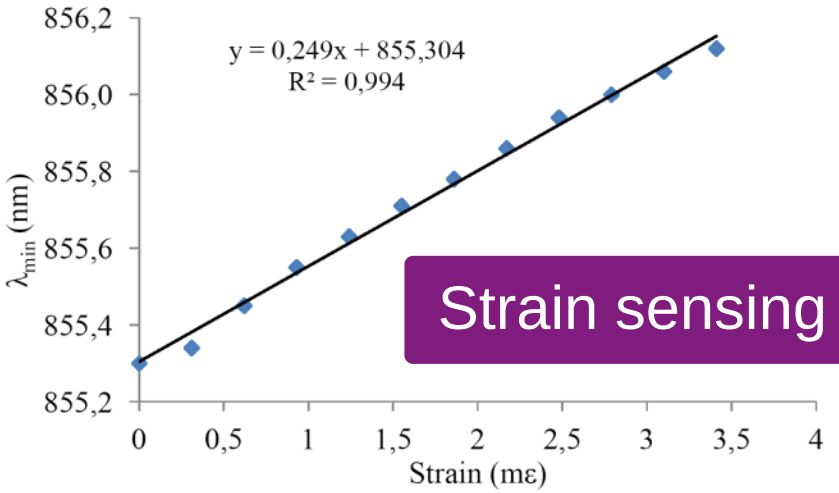
PHOSFOS
Photonic Skins For Optical Sensing

Tactile sensing



Vibrations





Strain sensing

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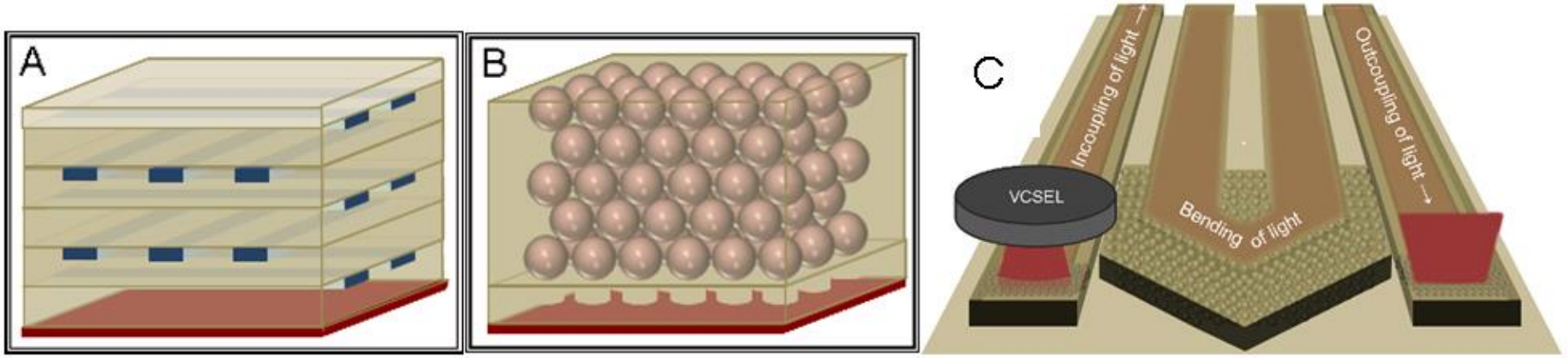
EU PROJECT FIREFLY
MULTILAYER PHOTONIC CIRCUITS

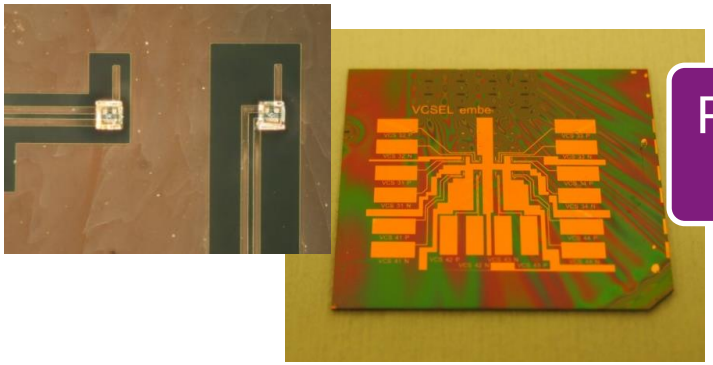
Challenges

- Integration of waveguides and VCSELs
- Integration of waveguides and glass fibers
- Integration of photonic crystals and waveguides



Multilayer Photonic Circuits made by Nano-Imprinting of Waveguides and Photonic Crystals

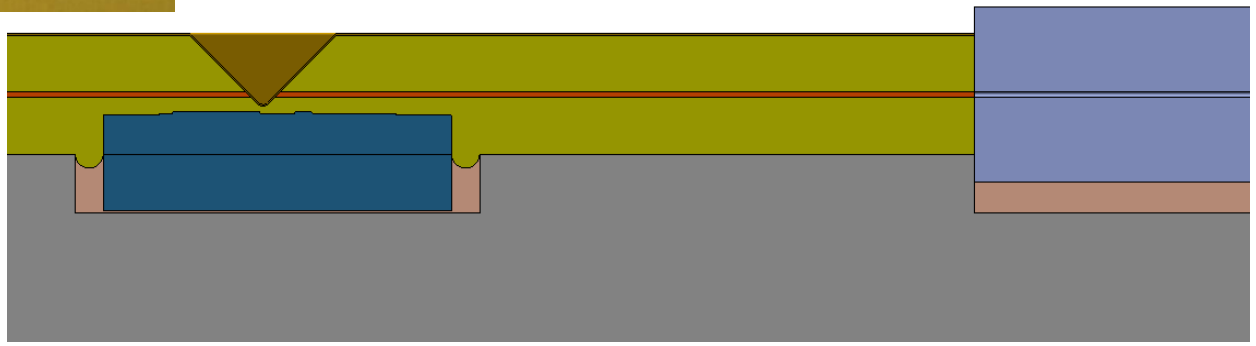
EU PROJECT FIREFLY
VCSEL – WAVEGUIDE INTEGRATION

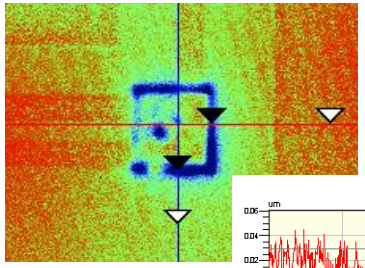


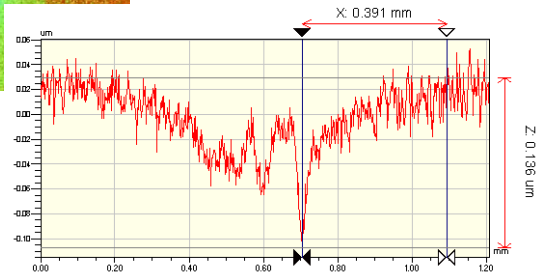
Face-up embedding of VCSELS

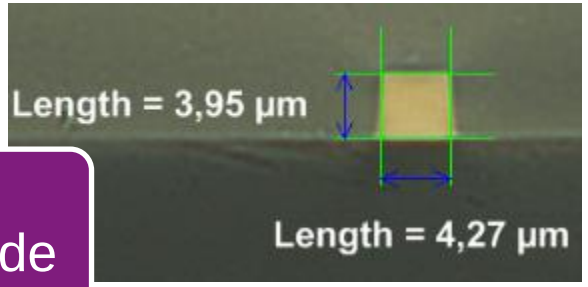
FIREFLY

Planarity after chip embedding









Single mode polymer waveguide technology

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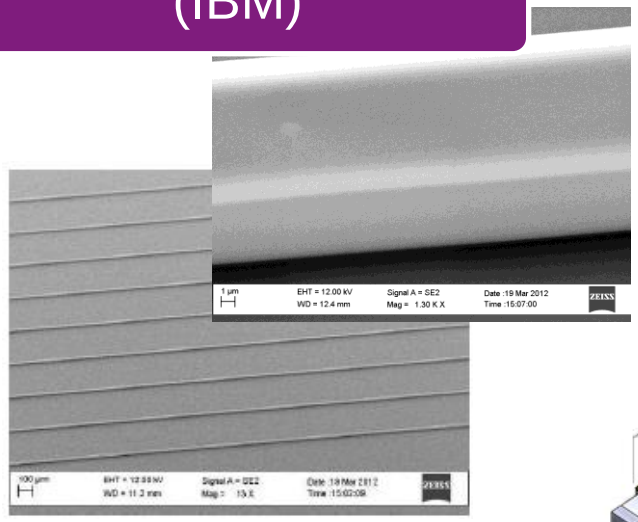
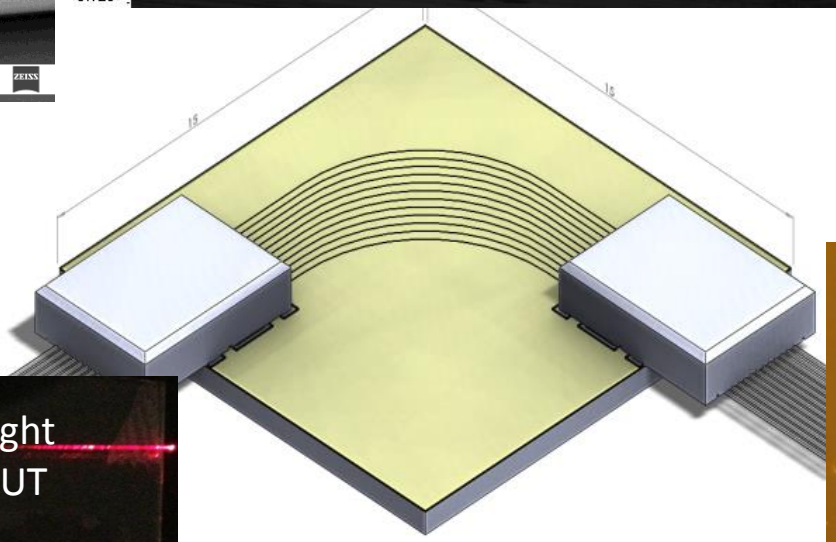
WAVEGUIDE – FIBER INTEGRATION

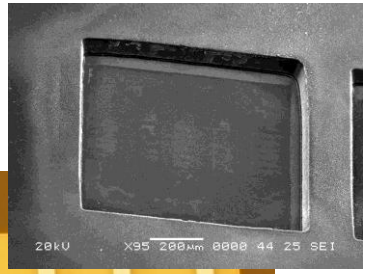
Laser direct writing (IBM)

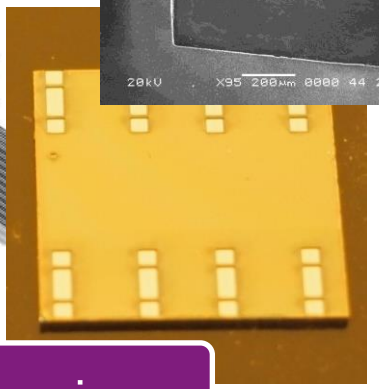


End facet (TE Connectivity)

FIREFLY







Initial testing (TE Connectivity)

Laser cleaning

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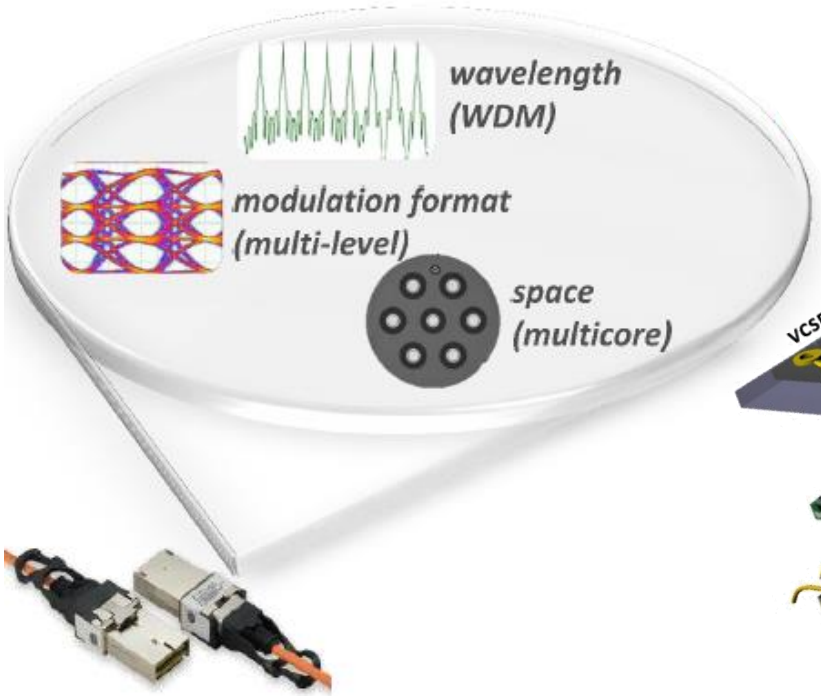
EU PROJECT MIRAGE
TERABIT CAPACITY AOC

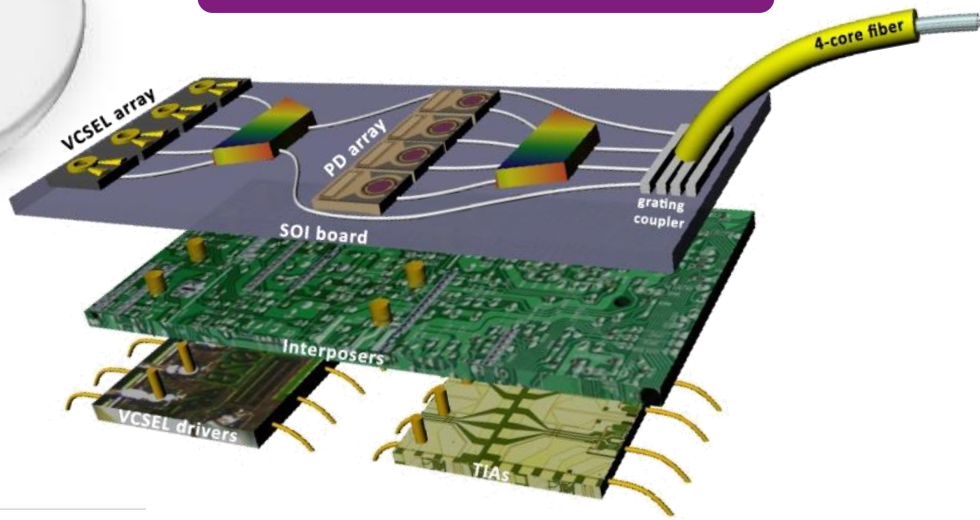
Scale line rate to 40G

Introduce new degrees of parallelization

- WDM | multi-core | multi-level



3D photonic-electronic integration



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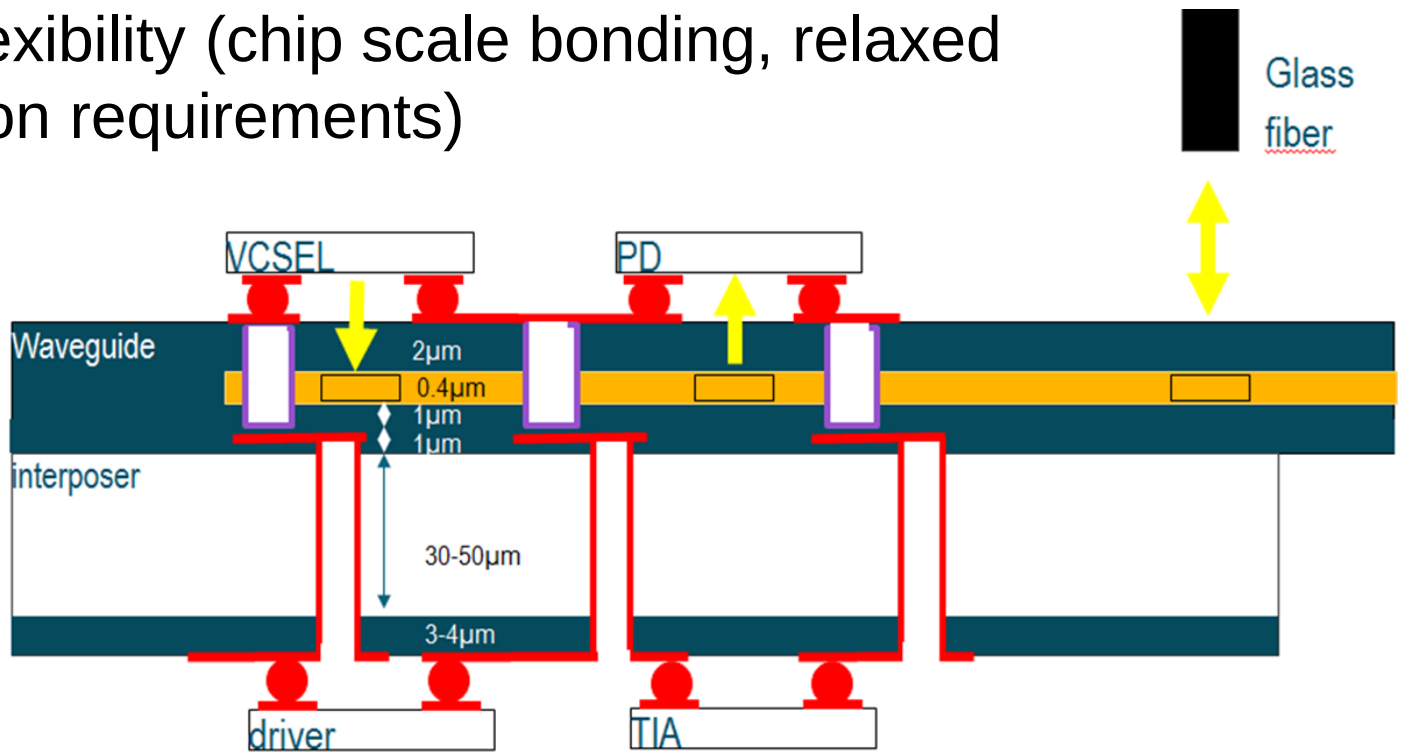
Optoelectronics assembly

- Control of vertical separation
- Low temperature bonding
- Process flexibility (chip scale bonding, relaxed metallization requirements)

Micro-bump flip chip



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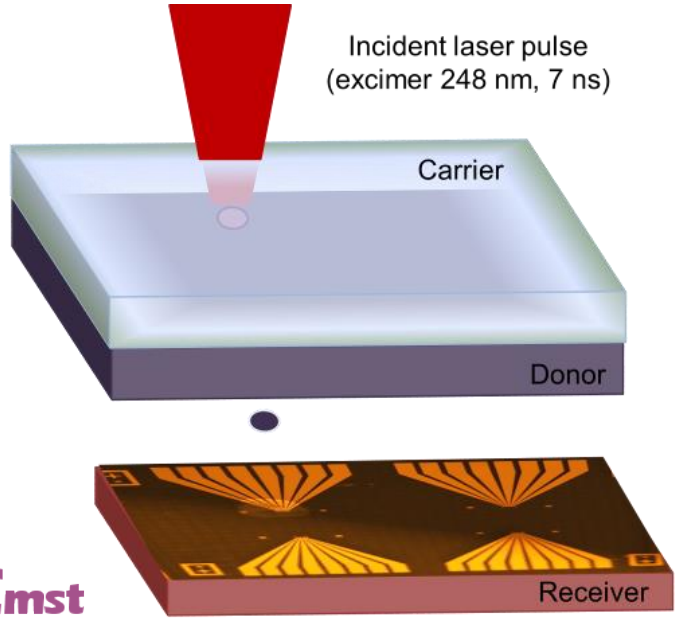
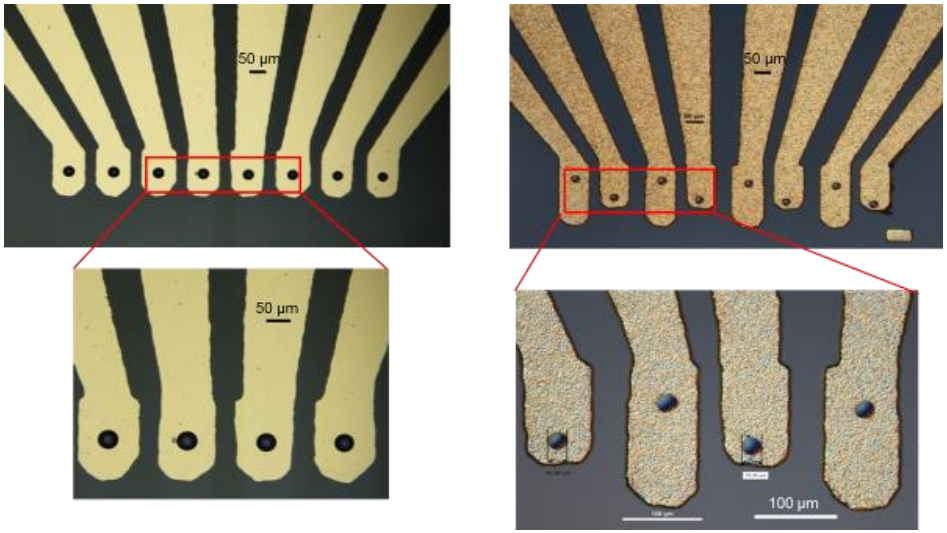
Optoelectronics assembly

- Accurately defining micro-bumps using

1 "Laser Induced Forward Transfer" (LIFT)





Adhesive bonding / thermocompression

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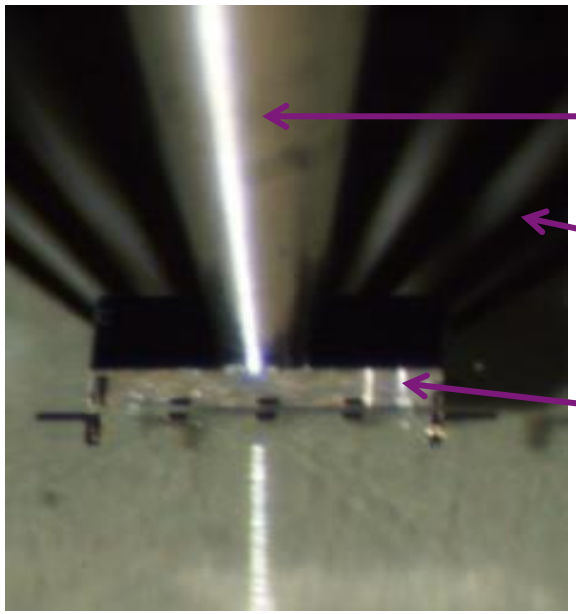
Optoelectronics assembly

- Flip chip bonding of the die

2

= chip placement + adhesive curing

+ thermo-compression bonding

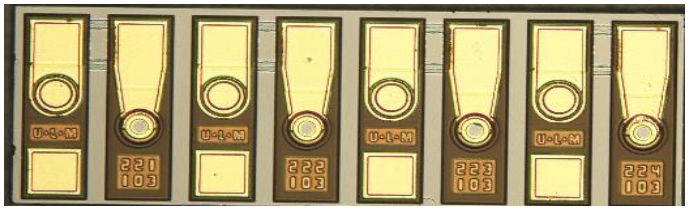


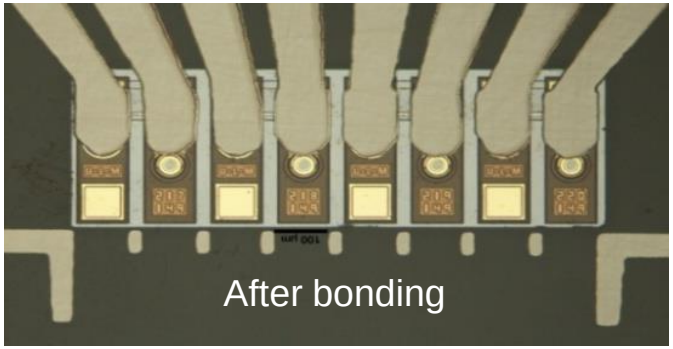
Flip chip bonder chuck

Substrate + metal tracks + adhesive bumps

OE chip (active area facing down)

VCSEL test chip (1x4 array)





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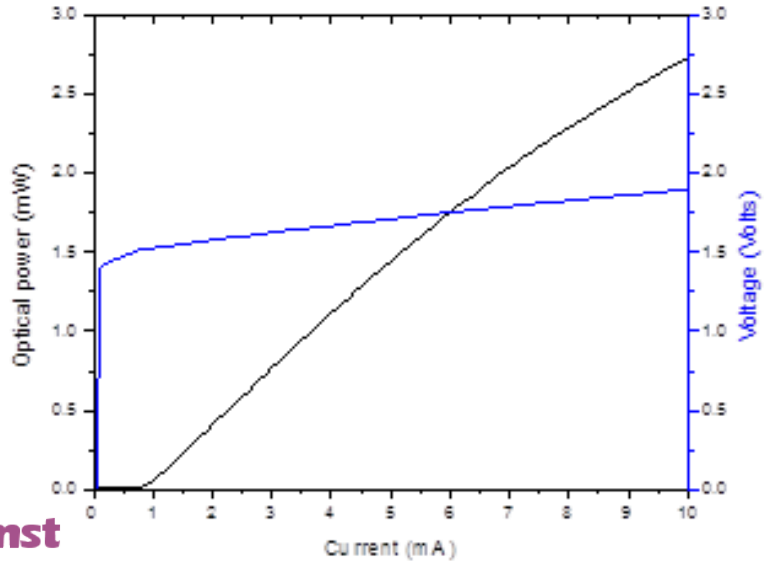
Optoelectronics assembly

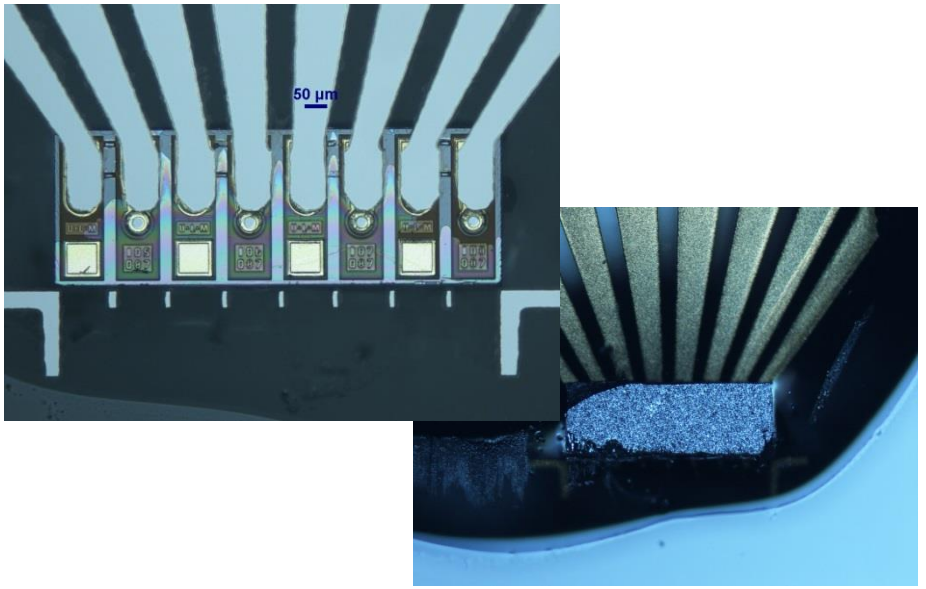
- Characterization of bonded VCSEL/PD chips
- Shear testing after bonding

3

LVI curve for bonded test VCSELs

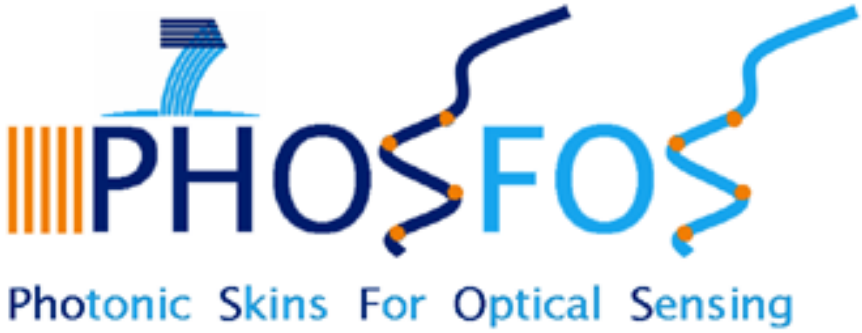


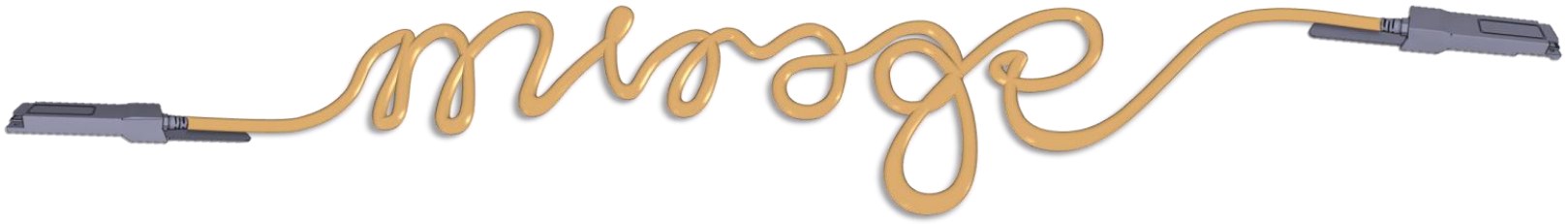
chip encapsulation
chip breaks during the shear test



ACKNOWLEDGEMENT

FIREFLY





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